

The science of climate change is an extraordinary example of a theory-driven, data-rich scientific paradigm, the likes of which, arguably, has not occurred since the development of quantum mechanics in the first half of the twentieth century. The product of this strong scientific framework is a body of strong, multifaceted evidence that man-made greenhouse gases are causing contemporary global warming, and that this warming trend is inducing large-scale changes in global climate. The primary evidence is based on physical principles and observational and experimental analysis of contemporary climate dynamics, as opposed to analyses of past climates, which are the subject of this hearing. We can now say with confidence that the evidence of human influence on climate is strong, as described by Dr. Cicerone.

Although paleoclimatology – the study of ancient climates – is an important part of the climate science frame work, reconstructions of temperature over the past millennium play a secondary, expendable role in the larger body of evidence, as stated in the recent NAS report titled, *Surface Temperature Reconstructions for the Last 2,000 Years*, **“Surface temperature reconstructions are consistent with other evidence of global climate change and can be considered as additional supporting evidence”** (National Research Council 2006, p. 23; hereafter referred to as the NAS report).

Dispensing with such reconstructions entirely or proving them fundamentally flawed would have little, if any, impact on our understanding of contemporary climate change. This statement does not imply that millennial climate reconstructions are unimportant, but their main influence will be in the future, when their potential to reveal how climate varied across the earth’s surface from year-to-year in the past is fully realized. At that point, such reconstructions will be used in a manor similar to thermometer records today.

This capability would contribute significantly resolving the current genuine debate in climate science, which is not about whether humans are changing the climate—a point over which there is no scientific controversy, but is about how much human influences will change the climate in the future as a result of greenhouse gas accumulation and other forcings we apply to the climate system. In other words, the goal of spatially explicit paleoclimate reconstructions is to help climatologists determine how physical forcings, such as solar radiation, volcanic eruptions, land-use changes, and changes in atmospheric greenhouse gases, have affected the planet in the past, so that we can improve estimates of how they will do so in the future.

The early MBH reconstructions (Mann et al. 1998; Mann et al. 1999; hereafter referred to as MBH98 or MBH99 or, collectively, MBH) were the first to offer spatially explicit climate reconstructions and therefore represented a breakthrough in climate change science that continues to develop and promises to further our understanding of climate physics in the future. Against this backdrop, the Wegman report's conclusion that paleoclimatology “does not provide insight and understanding of the physical mechanisms of climate change” (p. 52), fails to appreciate that in a complex field of science, it takes time to for a new initiative to realize its potential. Dr. Mann's research illustrates that federal funding of paleoclimate research over the past decade has directly led to the potential for spatially explicit data on past climate dynamics to improve our knowledge of physical mechanisms of climate change in the near future.

Turning our attention to the methodological issues this hearing seeks to investigate, I judge that the Wegman report failed to accomplish its primary objective, which was **“to reproduce the results of [McIntyre & McKittrick] in order to**

determine whether their criticisms are valid and have merit” (p. 7). Although the panel reproduced MM's work—verbatim—it only partially assessed the validity, and did not at all assess the merits, of the criticisms directed toward the MBH reconstructions. For instance, MM (Mcintyre and Mckitrick 2003; McIntyre and Mckitrick 2005; hereafter referred to collectively as MM) allege that the, so called, MBH “hockey stick” result is biased by methodological errors that undermine the conclusion that the late 20th century was uniquely warm relative to the past 1000 years. This critique only has merit if, after correcting for the errors pointed out by MM, the resulting reconstruction yields results significantly different from the original result that no longer support the claim of unusual late 20th century warmth. However, the Wegman Report takes no steps to make such a determination.

Fortunately, a different group, one highly qualified both statistically and climatologically to tackle this question of merit, had already performed the task several months before the Wegman Report was released. The study by Wahl & Ammann (In press; hereafter referred to as WA06), was peer-reviewed and accepted for publication in the journal, *Climatic Change*, early last spring, and has been publicly available in accepted form since last March (http://www.cgd.ucar.edu/ccr/ammann/millennium/refs/WahlAmmann_ClimChange2006.html). This study, titled, **Robustness of the Mann, Bradley, Hughes Reconstruction of Northern Hemisphere Surface Temperatures: Examination of Criticisms Based on the Nature and Processing of Proxy Climate Evidence**, carefully reproduced the MBH98 reconstruction and then, used their faithful reproduction to test MM's suggested corrections. They tested each of the criticisms raised by MM in all of their published papers, including both the peer-reviewed and non-peer-

reviewed papers. Given that this report specifically examined all of MM's criticisms, including the decentering issue that was the main focus of the Wegman report, it is unfortunate that the Wegman team dismissed it in a footnote (p. 48) as "not to the point."

WA06 have performed a meticulous and thorough evaluation of MBH98 and all the answers that this committee is seeking about the MBH reconstructions are to be found within this report. After examining each of MM's three methodological criticisms, WA06 accepted two of them as valid, and have used them to correct the MBH98 reconstruction. I will now show you what effect these corrections have on the MBH98 reconstruction, and then reconsider the uniqueness of the late 20th-century warming trend in the light of these corrections.

The original MBH98 "hockey stick" is shown as a gray line in (Fig. 1). In red, you see the WA06 reproduction of the MBH98 reconstruction. They used the MBH method and all of the original MBH data, including the original instrumental temperature series from 1992, to get this result. They wrote their own computer code to perform the calculations, using the R programming language, as recommended by the MM and the Wegman Report, rather than the original Fortran language used by Dr. Mann. As you can see, the two reconstructions are materially the same. This result demonstrates that MBH98 can be reproduced based on information available in the original MBH papers and supplemental information and data available on the Internet.

With this successful reproduction in hand, WA06 were able to test the effect of each of MM's criticisms on the outcome of the MBH98 reconstruction. After carefully considering the validity of MM's three criticisms of MBH's reconstruction methodology, WA06 agreed that 1) decentering the proxy data prior to PC analysis and 2) including the

poorly replicated North American Gaspé tree-ring series from 1400-1449 both biased the MBH results. After correcting for these biases, they obtained the results shown in blue (Fig. 2). The result is a slightly warmer (0.1 °C) early 15th century, with no other time period affected. The additional warmth in this period still does not approach the warmth of the late 20th century, so MM's critique cannot yet be said to have merit. However, the corrected MBH98 result creates the impression of an upward temperature trend backward in time before 1400, begging the question of what would happen to the Middle Ages in the 1000-year MBH99 reconstruction if it were also corrected for these biases.

Answering that question is requisite for determining the merit of MM's critique of MBH.

The original MBH99 reconstruction is shown in gray (Fig. 3). The corrected MBH99 reproduction is shown in red. Carrying the correction back to the full millennium reveals that in fact the largest bias occurred during the early 15th century, and both earlier and later periods were less affected. Therefore, there is very little difference between the corrected MBH98 and MBH99 reconstructions and the originals, and the original observation that the late 20th century is uniquely warm in the context of the past 1000 years is not affected. Hence, the valid methodological caveats that MM pointed out do not undermine the main conclusions of the original MBH papers or the conclusion of the 2001 IPCC assessment. There simply is no signal in the proxy data for a hemisphere-wide Medieval Warm Period.

The scientific debate over the MWP has been on the same trajectory for at least 20 years, with early indications that the MWP was not a globally coherent event become more solid over time. The MBH99 reconstruction represented an evolutionary step—not a revolutionary change—in this established trajectory. The 1990 IPCC figure that Mr.

McItyre, the *Wall Street Journal* editorial page, and Dr. Wegman have displayed is a cartoon, as stated by Dr. Wegman in his testimony last week, that ends in 1975. I have confirmed this with a number of individuals who were involved with the 1990 IPCC report or with versions of the schematic that pre-dated the 1990 IPCC report. It is not a plot of data and is inappropriate as a comparison to MBH. The text of the 1990 IPCC report clearly states that the figure is a "schematic diagram" and that "it is still not clear whether all the fluctuations indicated were truly global" (p. 202). Furthermore, only three sources of information were cited and those sources conflicted on whether the Northern Hemisphere was warm or cold: **"The late tenth to early thirteenth centuries... appear to have been exceptionally warm in parts of western Europe, Iceland and Greenland... China was, however, cold at this time, but South Japan was warm..."** Clearly, this report certainly did not paint a picture of any consensus regarding a Medieval Warm Period as a hemisphere-wide phenomenon and characterizing it as such reveals a fundamental misunderstanding of climate science.

The 1992 and 1995 IPCC reports continued this same trajectory of thought. Four years before MBH99, citing 6 papers—still a very limited number by twice as many as were cited in 1990—the 1995 report stated:

There are, for this last millennium, two periods which have received special attention, the Medieval Warm Period and the Little Ice Age. These have been interpreted, *at times*, as period of global warmth and coolness, respectively. Recent studies have re-evaluated the interval commonly known as the Medieval Warm Period to assess the magnitude and geographical extent of any prolonged warm interval between the 9th and 14th centuries... The available evidence is limited (geographically) and is equivocal. ...a clearer picture may emerge as more and better calibrated

proxy records are produced. However, at this point, it is not yet possible to say whether, at a hemispheric scale, temperatures declined from the 11-12th to the 16-17th century. Nor, therefore, is it possible to conclude that the global temperatures in the Medieval Warm Period were comparable to the warm decades of the late 20th century” (p. 174).

Remember that this was written by a team of climatologists as a consensus statement.

The consensus at this time, as in 1990, was that there was no strong evidence of a hemisphere-wide MWP.

Continuing the same trajectory, the 2001 IPCC Third Assessment Report examined evidence from 10 cited sources for the MWP. The consensus at this point seemed to be turning to the conclusion that there actually was a generally warm Northern Hemisphere during the Middle Ages, but that it was not a strong, coherent pattern of warming:

It is likely that temperatures were relatively warm in the Northern Hemisphere as a whole during the earlier centuries of the millennium, but it is much less likely that a globally-synchronous, well defined interval of “Medieval warmth” existed, comparable to the near global warmth of the late 20th century... Marked warmth seems to have been confined to Europe and regions neighboring the North Atlantic.

Since the MBH reconstructions were hemisphere-wide, and the MWP probably was not, it should not surprise us that the reconstructions lack a strong MWP (MBH99 does show slightly warmer temperatures in the 9th to 14th centuries than in the 15th to 19th centuries).

All available evidence indicates that the situation during the Middle Ages was fundamentally different than what is happening with climate today, which is a well-documented, globally coherent warming trend that is happening North, South, East, and West; at low latitudes and high latitudes; over land and over sea. There is even new data,

published earlier this year, indicating that the atmosphere above Antarctica has warmed dramatically in recent decades (Turner et al. 2006). There is no large region on earth where large-scale 20th century warming has not been detected, which simply cannot be said of the MWP.

Wahl and Ammann (2006) have demonstrated that the results of MBH are robust “down in the weeds”:

Our examination does suggest that a slight modification to the original Mann et al. reconstruction is justifiable for the first half of the 15th century ($\sim +0.05^\circ$), which leaves entirely unaltered the primary conclusion of Mann et al. (as well as many other reconstructions) that both the 20th century upward trend and high late-20th century hemispheric surface temperatures are anomalous over at least the last 600 years.

The NAS has affirmed the MBH results are also robust in the bigger picture, as well:

The basic conclusion of MBH99 was that the late 20th century warmth in the Northern Hemisphere was unprecedented during at least the last 1,000 years. This conclusion has subsequently been supported by an array of evidence that includes both additional large-scale surface temperature reconstructions and pronounced changes in a variety of local proxy indicators, such as melting on icecaps and the retreat of glaciers around the world, which in many cases appear to be unprecedented during at least the last 2,000 years. Not all individual proxy records indicate that the recent warmth is unprecedented, although a larger fraction of geographically diverse sites experienced exceptional warmth during the late 20th century than during any other extended period from A.D. 900 onward. (p. 3)

Examination of the IPCC reports through time, as well as the primary scientific literature, reveals why the MBH results are so robust—MBH simply assimilated all the

available evidence into a quantitative reconstruction—evidence that had already been evaluated qualitatively as lacking a coherent MWP.

This committee is seeking to know the significance of the criticisms leveled at the MBH reconstruction for climate change assessments. The significance is that these criticisms have resulted in the most thoroughly vetted single climate study in the history of climate change research. Dr. Tom Karl summarized the impact most succinctly in his testimony to this committee last week when he said that he would stand by the IPCC's assessment as originally stated in the report [CAN I GET A QUOTE FROM KARL'S TESTIMONY???]. Hence, the impact of the MM critique, after being scrutinized by the NAS, the Wegman panel, and a number of meticulous individual research groups, is nil with regard to the main conclusions of MBH and the 2001 IPCC.

Also relevant to this committee's questions about climate change assessments is the revelation that climate scientists do know their business, and that a lack of knowledge of geophysics is a genuine handicap to those who would seek to provide what they deem "independent review." If the assessment of climate science presented in Mr. McIntyre's presentation to the NAS committee, the Wegman Report, and the WSJ is an example of what can be expected from those who have not conducted climate research, then the investigation launched by this committee has demonstrated clearly that "independent review" by non-climate scientists is an exceedingly ineffective way to make climate change assessments.

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